Phosphorus in Pulse Production

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Pulse Crops and Their Contribution to Soil Fertility:

IT ALL STARTS HERE!

Nodules that form on legume roots containing superior strains of N fixing bacteria **fix N** for **legume crop** and <u>contribute to N nutrition of following crop.</u>

Phosphorus is important for N fixation!

What About Phosphorus?

- Legumes can often mobilize and access P already present in the soil better than many other crops can.

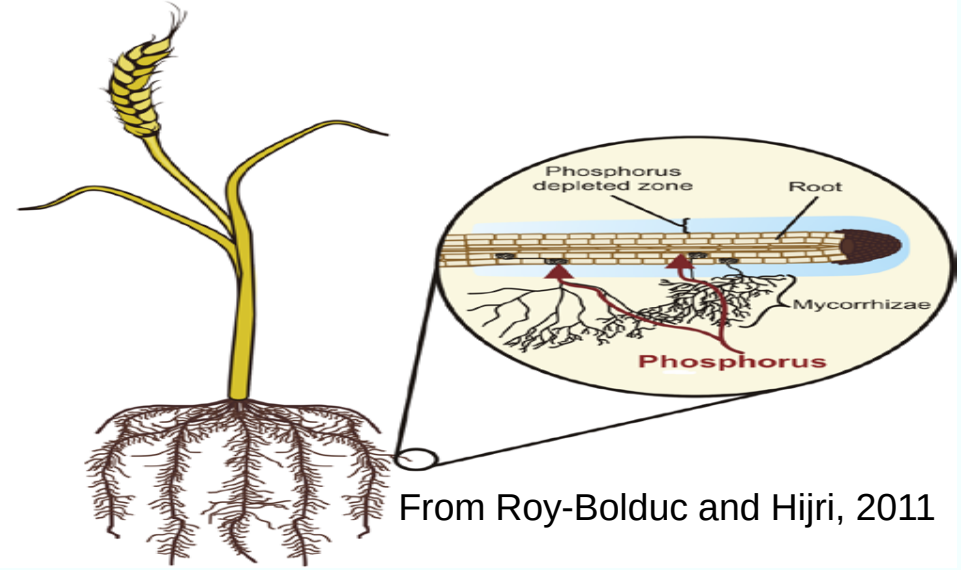
- Legumes are known to have the ability to solubilize P from less soluble forms in the soil (Hassan et al., 2012).

- Legume roots can acidify root zone and solubilize calcium phosphates common in prairie soils.

- Explains why pulses are sometimes not highly responsive to P fertilization. **Good scavengers**

Phosphorus mobilization by legumes

- Rhizosphere acidification or alkalization
- Phosphate releasing enzymes
- Morphological root traits
- Inoculation with P solubilizing fungi: *P. bilaii*
- Symbiotic relationship with arbuscular mycorrhizal fungi that can also benefit the following crop



From Roy-Bolduc and Hijri, 2011

Pulses have high phosphorus requirements

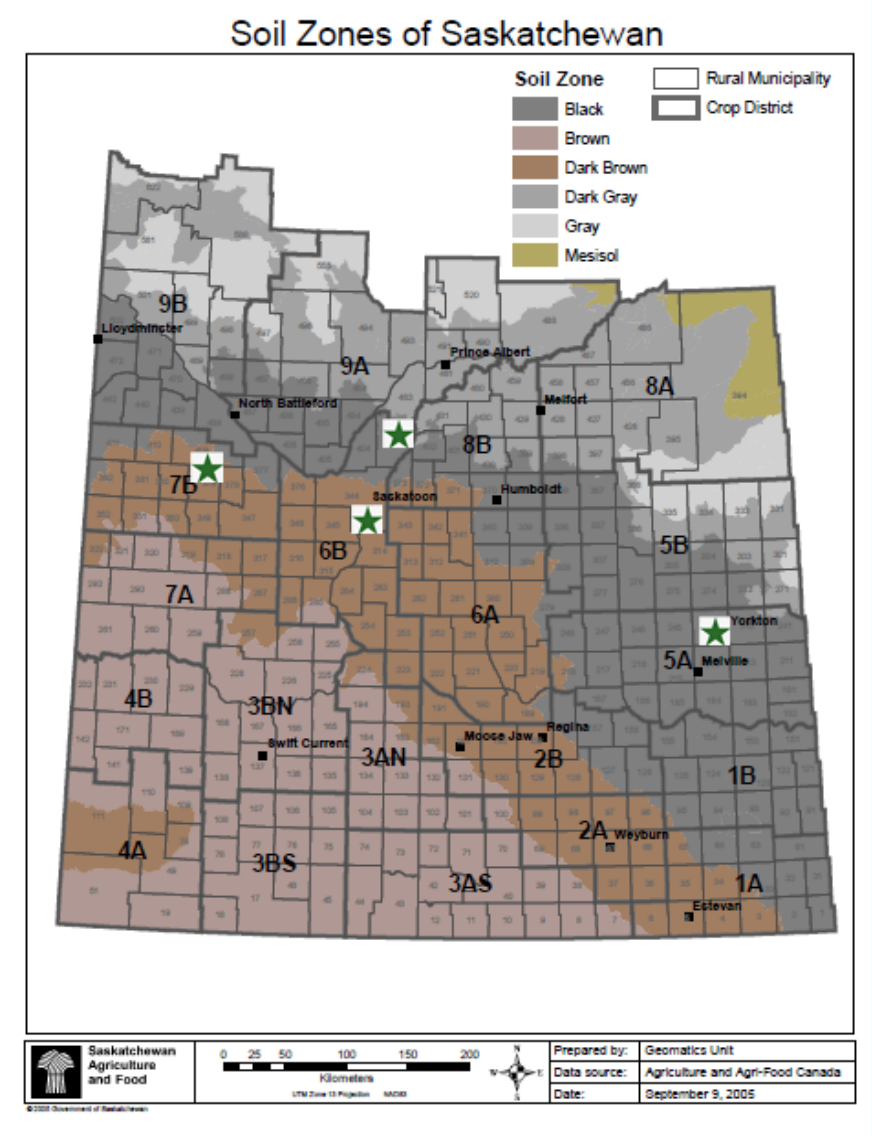
- N fixation takes energy!

Harvesting good yields means significant crop P removal:

	Phosphorus content *lbs P_2O_5 / acre*	
	Grain	**Straw**
Pea 40bu/ac	30	10
Soy 40bu/ac	35	12
Lentil 30bu/ac	20	5
Faba 50bu/ac	60	40

Pulse Nutrient Uptake at Four Sites in Saskatchewan in 2014

J. Xie PhD thesis research



Four field sites:

- Saskatoon (Dark Brown)
- Scott (Dark Brown)
- Rosthern (Black)
- Yorkton (Black)

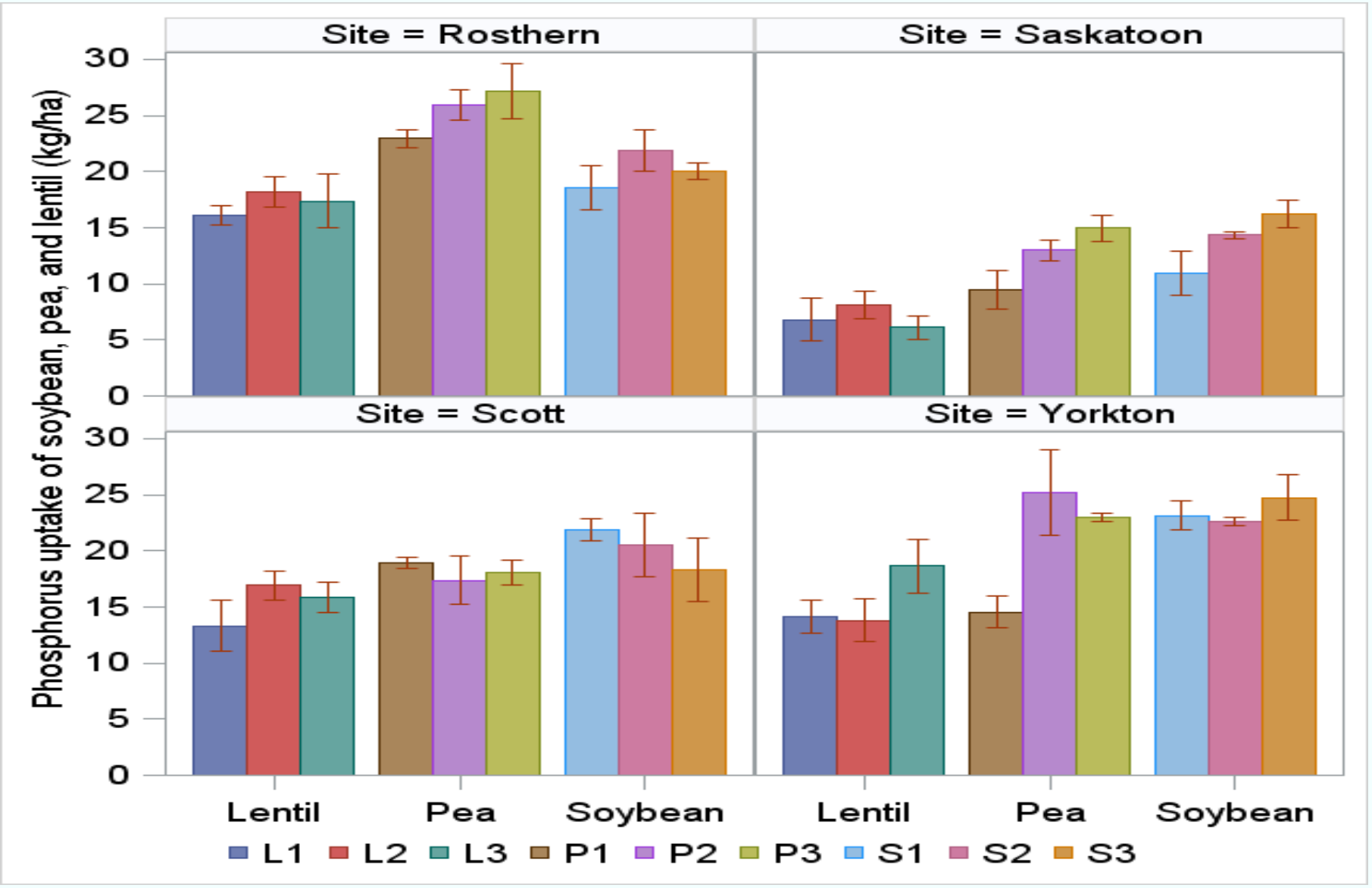
Experimental design:

- Randomized complete block design (RCBD)

Basic information on crop varieties in the field study

Crop	Variety	Market class	Breeder	Herbicide resistance	Variety #	^{15}N-study
pea	CDC Meadow	yellow	CDC	group 2	P-1	√
pea	CDC Amarillo	yellow	CDC	group 2	P-2	×
pea	CDC Limerick	green	CDC	group 2	P-3	×
lentil	CDC Impower	large green	CDC	group 2	L-1	×
lentil	CDC Imvincible	small green	CDC	group 2	L-2	×
lentil	CDC Maxim	small red	CDC	group 2	L-3	√
soybean	P001T34R	oilseed	Pioneer Dupont	group 2	S-1	×
soybean	TH3303R2Y	oilseed	Thunder	group 2	S-2	√
soybean	NSC Moosomin	oilseed	Northstar Genetics	group 2	S-3	×
wheat	CDC Abound	hard red	CDC	group 2	W	√

P requirement: soy = pea > lentil

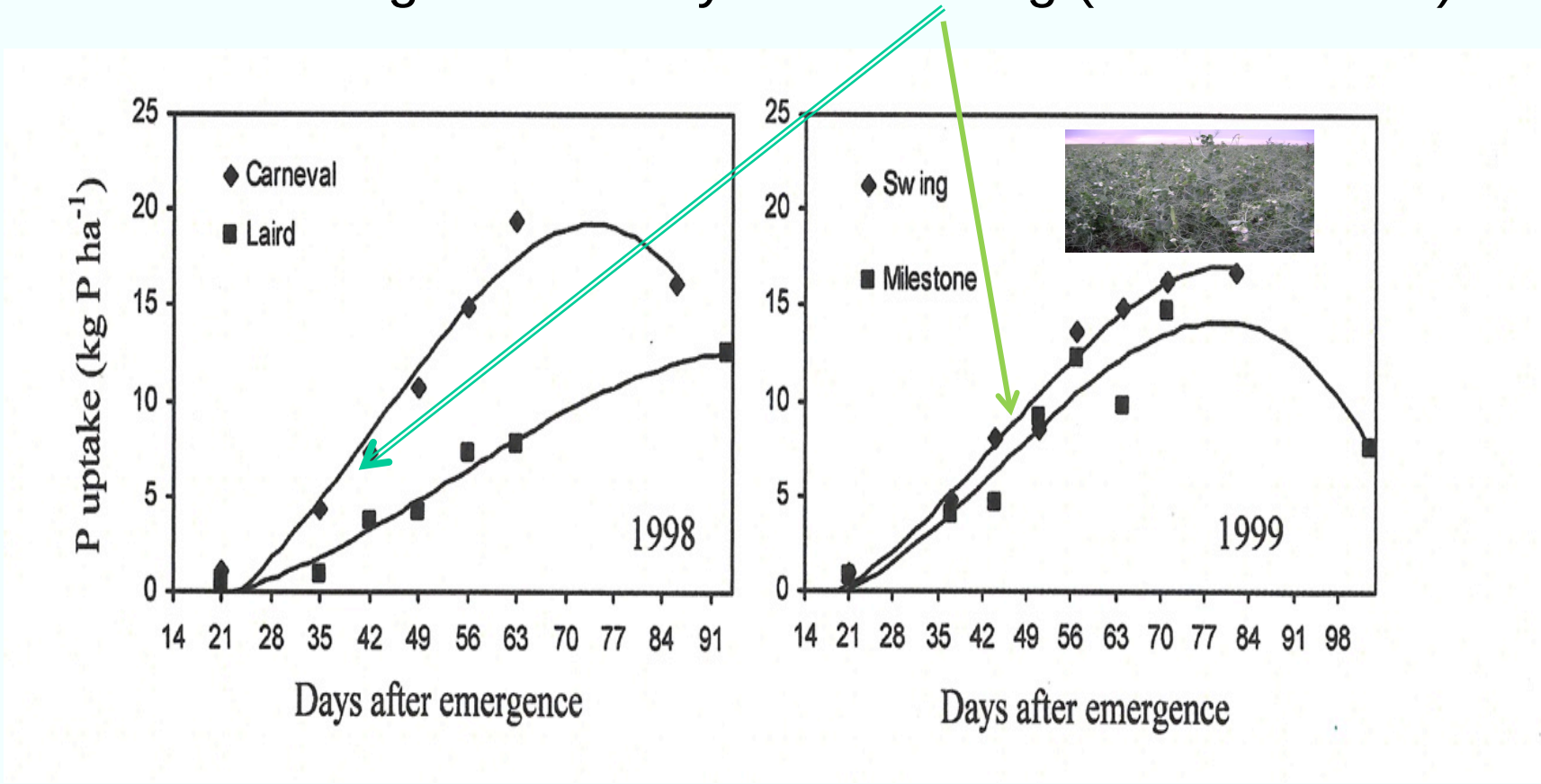


Above ground (grain + straw) P uptake (kg P/ha).

Note: Multiply by 2.3 to get kg P_2O_5/ha

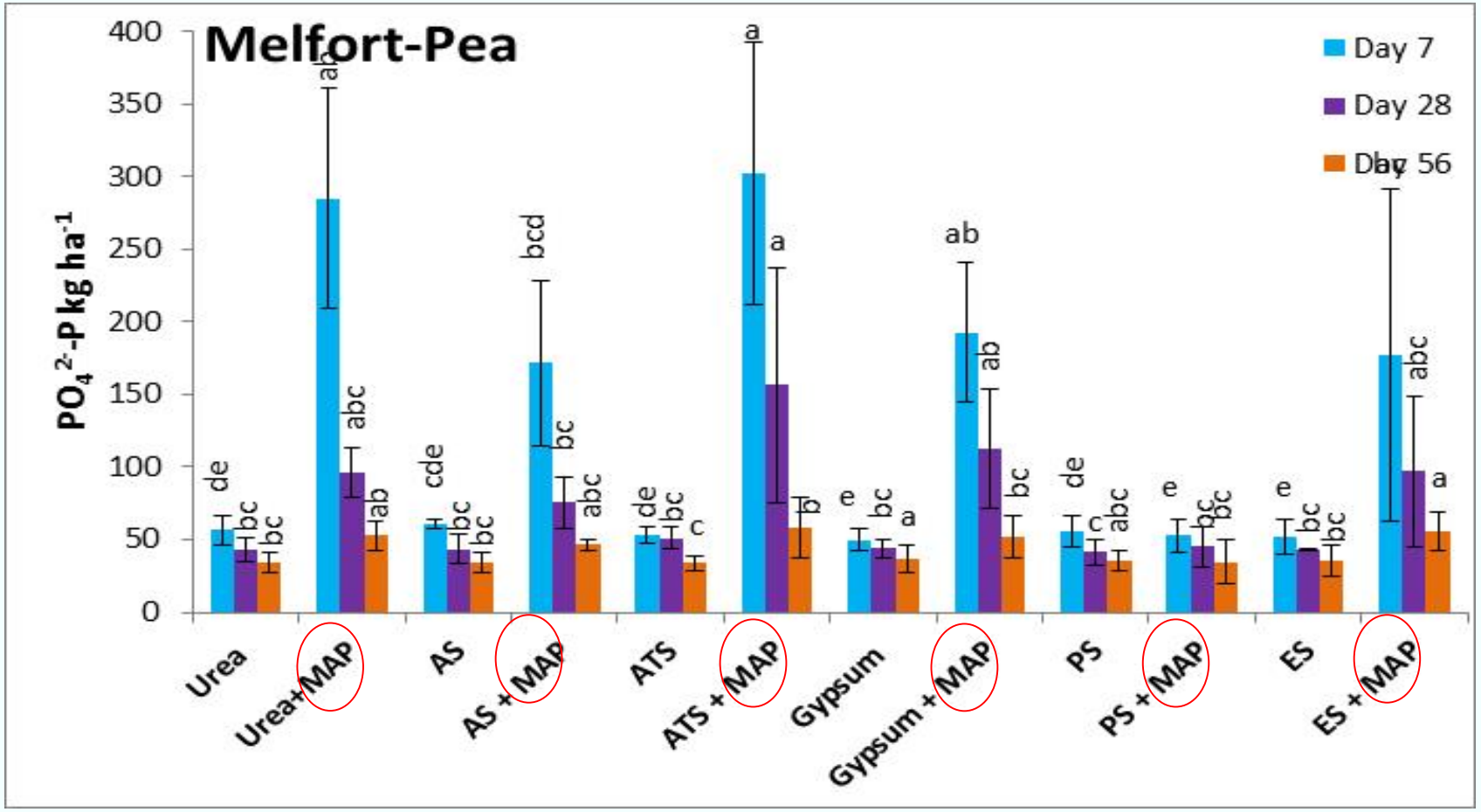
Pulse crops take up P early on in growth:

For pea and lentil, maximum accumulation rate was 0.2 to 0.5 kg P / ha / day at branching (28 to 49 DAE)



Malhi et al. 2007. Journal of Plant Nutrition 30: 721-737

Extractable phosphate in seed-row 7, 28 and 56 days after seeding peas



Pulse crops respond to starter P fertilizer

- 15 kg P_2O_5 / ha reported to benefit early growth and sometimes lentil yield (Bueckert et al.; Gan et al.).
  - Same with other pulses (e.g. Walley et al chickpea; Henry et al, McKenzie et al. peas).

- Greatest likelihood of response on soils with low available P supply, cold, wet or dry soil and when frequency of non-mycorrhizal crops (e.g. Brassicae) in rotation is high.

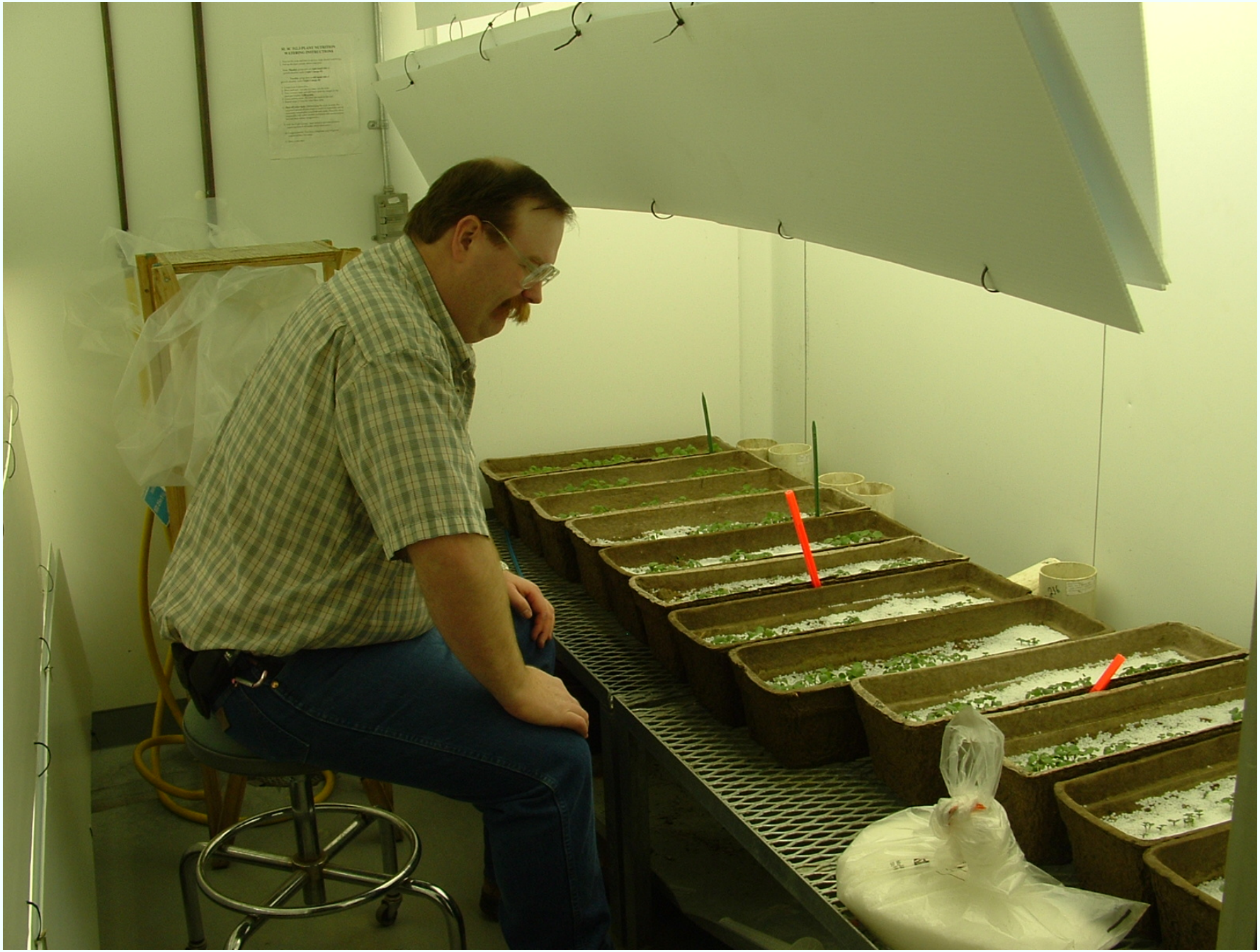
- Soil P availability assessment a useful tool.

Pulse crops have different tolerances to seed-placed fertilizer P

With ~ 15% seed bed utilization (e.g.1" spread opener, 9" spacing), max safe rates according to provincial guidelines:

Pea	15 lbs P_2O_5/ac
Lentil, Chickpea	20 lbs P_2O_5/ac
Fababean	40 lbs P_2O_5/ac
Soybean (limited SK research)	20 lbs P_2O_5/ac

Note: Crop removal can exceed safe rates, esp. for pea, bean

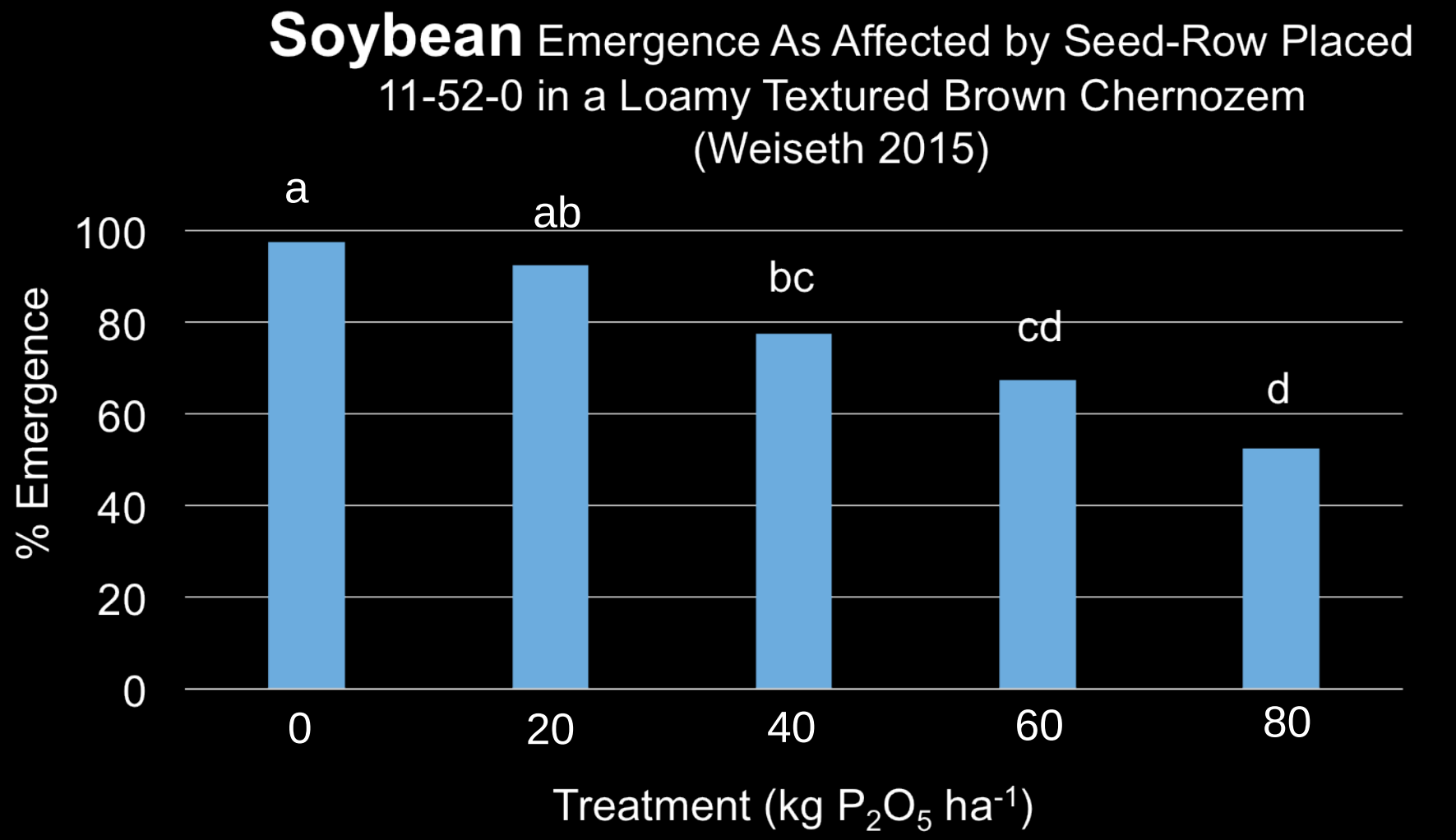


% of seeds planted that emerged over two weeks

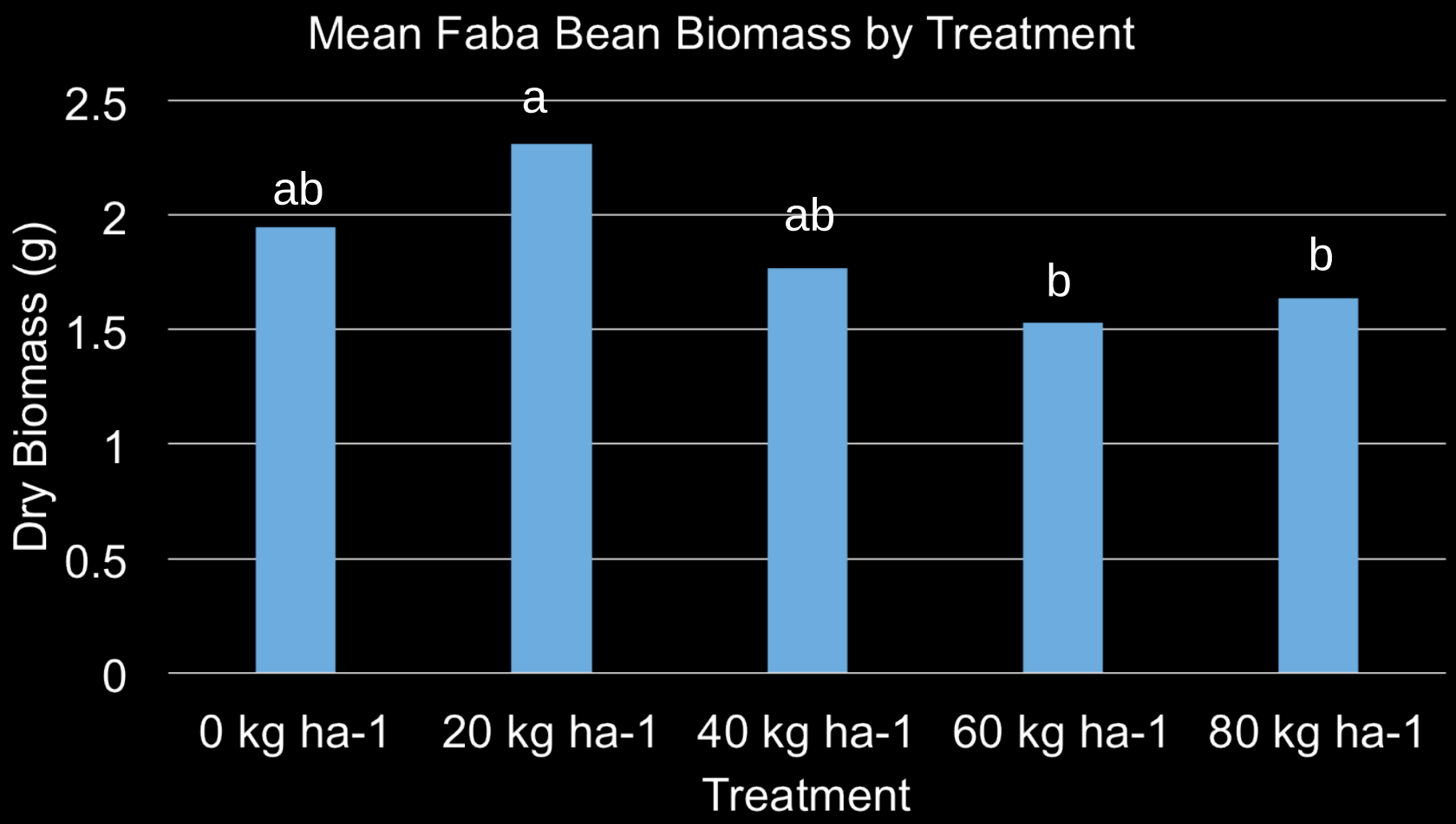
as affected by different rates of P alone (P) as MAP and P combined with 20 kg K_2O/ha (P+K) as KCl

(values in a column followed by the same letter are not significantly different)

P Fert 11-52-0	Yellow Pea		Green Lentil	
kgP_2O_5/ha	P	P+K	P	P+K
0	97a	*75a*	88a	88a
10	76ab	*68ab*	83a	85a
20	75ab	*54bc*	90a	81a
30	72b	*39cd*	85a	81a
40	56b	*25de*	77ab	52b
60	28c	*18e*	63bc	52b
80	19c	*11e*	58c	33bc
100		*11e*	29d	29c


Soybean Emergence As Affected by Seed-Row Placed 11-52-0 in a Loamy Textured Brown Chernozem (Weiseth 2015)
a
ab
bc
cd
d
100
80
60
40
20
0
% Emergence
0
20
40
60
80
Treatment (kg P_2O_5 ha^{-1})

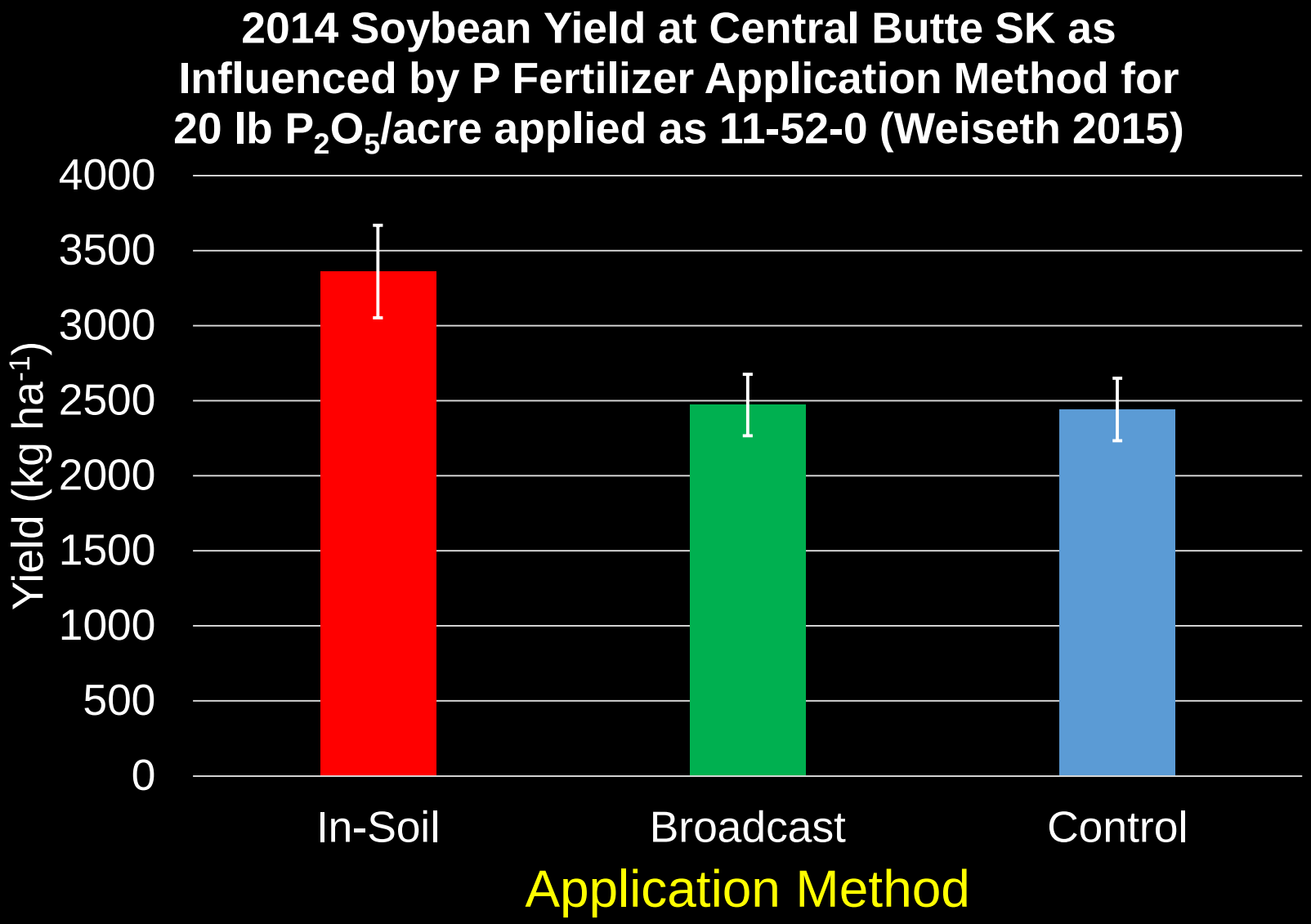
P<0.0001


Mean Faba Bean Biomass by Treatment
Dry Biomass (g)
2.5
2
1.5
1
0.5
0
ab
a
ab
b
b
0 kg ha-1
20 kg ha-1
40 kg ha-1
60 kg ha-1
80 kg ha-1
Treatment

P=0.01

Fertilizer P Placement Influences Pulse Response

- Get it in the ground!


2014 Soybean Yield at Central Butte SK as Influenced by P Fertilizer Application Method for 20 lb P_2O_5/acre applied as 11-52-0 (Weiseth 2015)
4000
3500
3000
2500
2000
1500
1000
500
0
Yield (kg ha^{-1})
In-Soil
Broadcast
Control
Application Method

Pulses in Rotation and Phosphorus

What are effects of legumes on P nutrition of following crops?

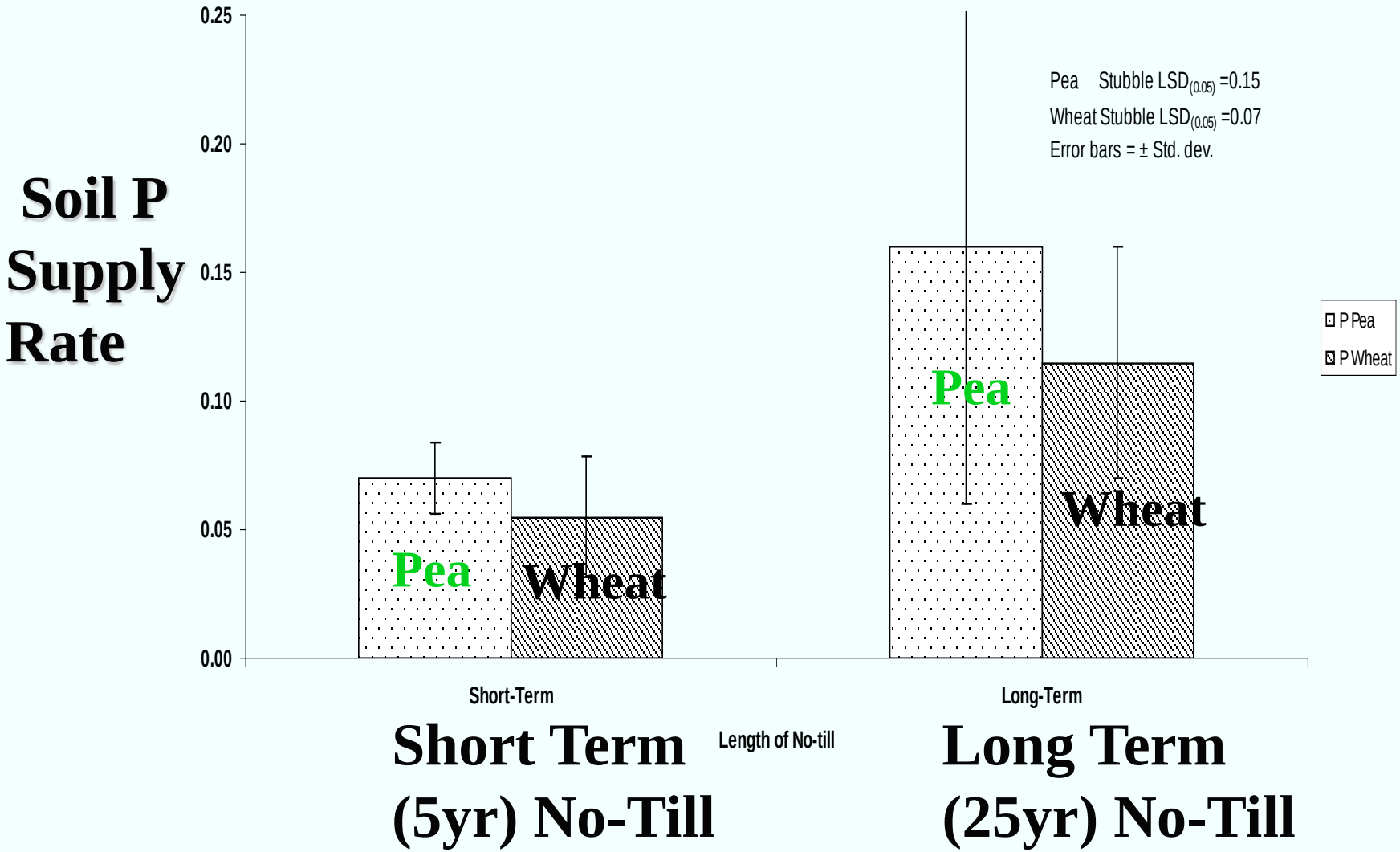
- P uptake by non-legume generally increased following legume versus non-legume

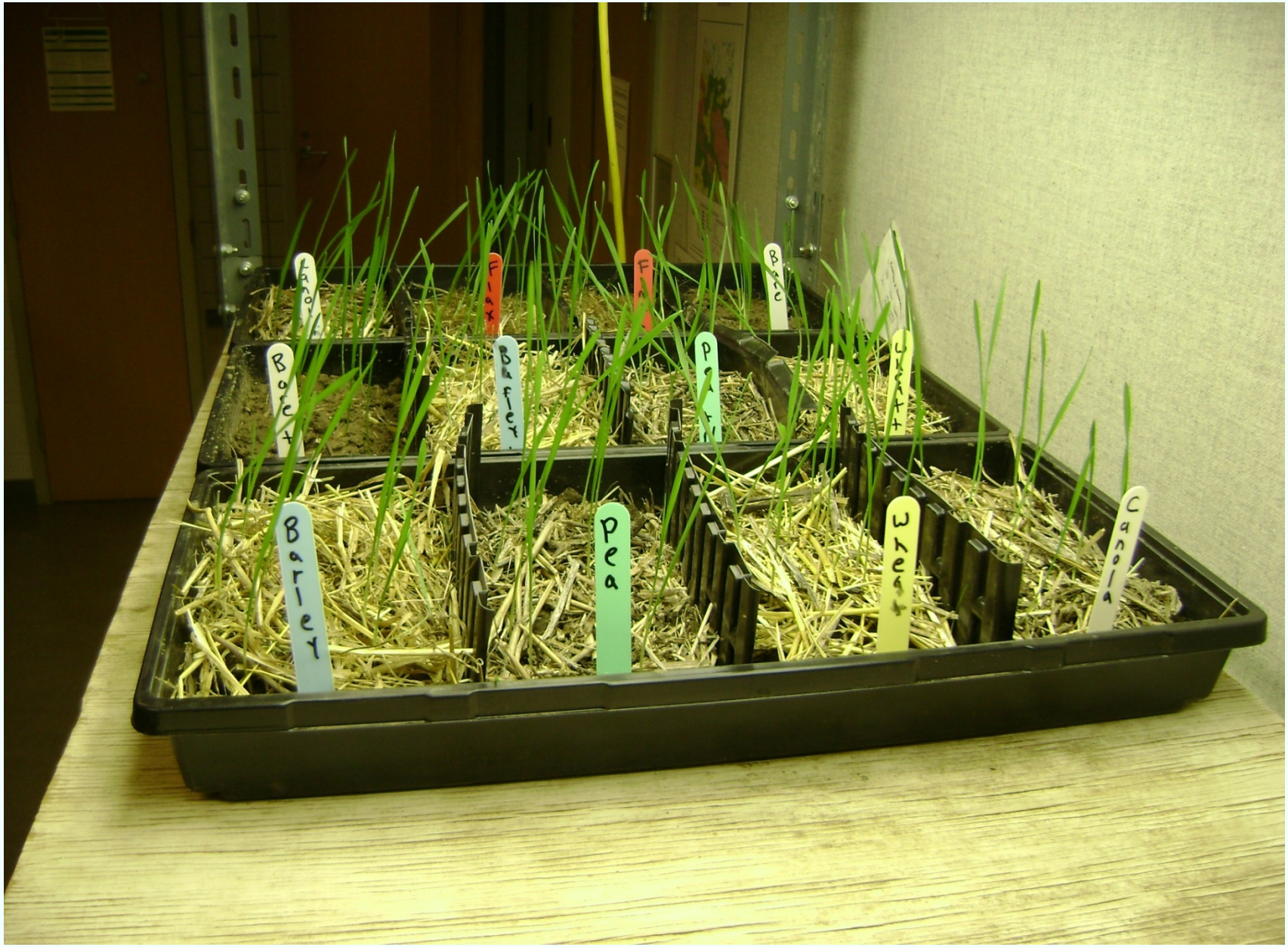
  (pulse: Sulewski et al; forage: Rehmut et al. 2014).

Possible Reasons

- **Increased soil P availability**
- **Increased colonization of roots by beneficial AM fungi**
- **Improved root growth and crop demand**

Available Phosphorus Supply Rate At Indian Head SK Plots




Barley
Pea
Wheat
Canola

- All crop residues reduced P and N availability initially due to microbial tie-up.

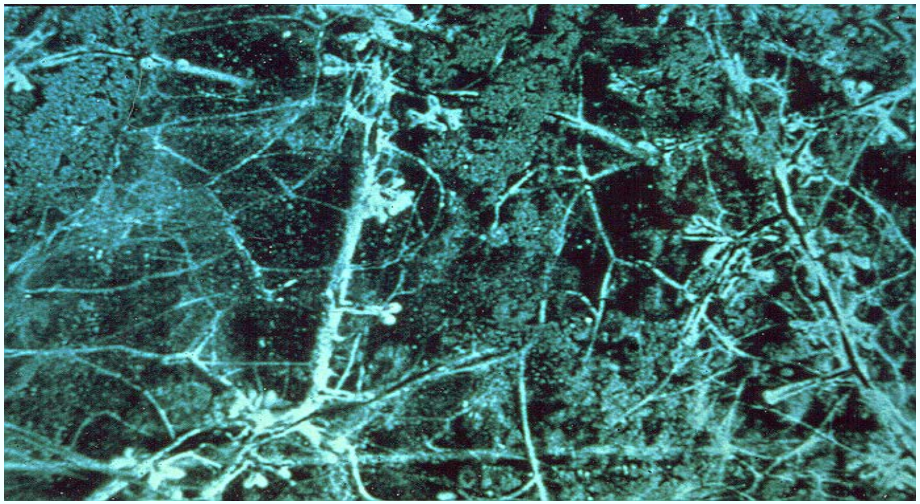
- **Pulse residue resulted in less P and N tie-up than cereal residue.**

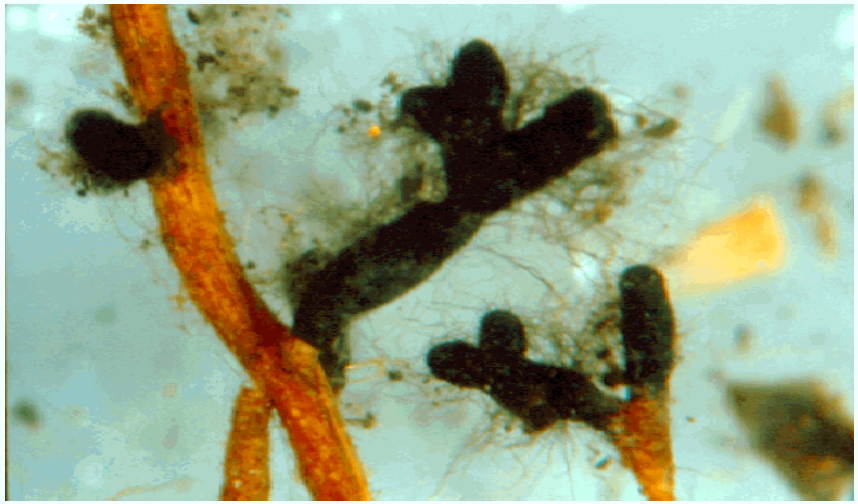
- Over the season, amounts of P released from above ground residues **were only about 1.0 lb P/acre** from chickpea and pea residue.

Contribution of above-ground pulse residue to P nutrition of following crop is rather small.

Important benefit of pulse can be enabling greater access to soil P and other nutrients by the following crops:

Better rooting environment, root health, beneficial biological associations (AM fungi).





A benefit that is rather difficult to directly measure!

The magic of pulses!

Thanks for opportunity to participate!

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